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The pollen-tube in some of the Cucurbitaceae *

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(WITH PLATES 16 AND 17)

In a previous paper on the embryology of the Cucurbitaceae [14] it was the writer's intention to deal with the matters suggested in the present title, but lack of evidence on certain points, and other causes, necessitated their omission at that time. It is hoped here to discover some of the controlling factors in the behavior of the pollen-tube in *Melothria*, *Micrampelis* and *Cyclanthera*, one species of each.

The various phases of the development of the pollen-tube have been studied by numerous writers in widely differing subjects, but until recently little has been done to determine the nature of the influence which directs the pollen-tube in its growth. The conclusions, however, based upon anatomical and experimental evidence, have been by no means unanimous, and much still remains to be done in this field of investigation.

The behavior of the pollen-tube has been seen to vary considerably in different groups. The manner in which it approaches the embryo-sac in different cases has led Pirotta and Longo [27] to recognize three distinct conditions: acrogamy, in which the pollen-tube enters the micropyle, a condition obtaining in the majority of seed plants; basigamy, including those cases in which the tube enters by way of the chalaza, occurring in the Amentiferae; and mesogamy, which thus far has been found in a few cases only and applies to those instances in which the tube enters the nucellus by

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some other route, *i. e.*, traversing the tissues of the funicle and integuments. Such conditions have been observed in *Cucurbita* and *Alchemilla*.[23]

In its course from the stigma to the ovule, the pollen-tube may follow a canal through the style where such is available, and intercellular spaces as well, or it may bore through a considerable amount of cellular tissue, which it may or may not affect injuriously. Its course is usually a direct one and the direction of its growth is often influenced mechanically by the structure of the ovary as well as by the distribution of nutritive materials in what has been called conducting-tissue. The influence of the latter as a directing agent has received some attention at the hands of Miyoshi[20],[21] and others whose work we will discuss more fully later, but the results from various sources go to show that in considering the growth of the pollen-tube we are dealing with problems of chemotropic irritability and the action of stimulating substances whose distribution is indicated largely by anatomical features.

While the pollen-tube in angiosperms is ordinarily devoid of branches, a few cases have been observed in which the tube has divided into a number of branches after having reached the ovule. Hofmeister[13], describes the branching of the tubes in *Pothos* and *Hippeastrum*, and in the Amentiferae it has been observed in *Corylus*, *Carpinus*[3], *Juglans*[25], *Hicoria* (*Carya*)[4], *Quercus*[3] and several others. It occurs also in *Cucurbita* as described by Longo[17], and observed by the author. That the branching is associated with the function of absorption has been the accepted view, and the observation of Longo that the branching is in a definite relation to the presence and distribution of starch in adjacent tissues supports this opinion.

Numerous observations have been made on different plants as to the time consumed by the pollen-tube in traversing the distance from the stigma to the embryo-sac. This has been found to vary within wide limits and to be dependent upon no fixed principle except that the immediate approximation of the germ cells is correlated with their degree of maturity. In certain herbaceous plants the time required varies from eighteen hours (*Limnocharis*[12]) to several days (*Crocus*, *Arum*[13]) and even much longer, as in certain

orchids, the difference in time being in no relation to the distance traversed. Among woody plants the time between pollination and fertilization has been observed to vary from one month (*Betula*[3]), to several months (*Hamamelis*)[30], and Conrad[7] has shown that it is over a year in *Quercus*. It has been shown that in those cases where a longer time is required the pollen-tube passes through a more or less protracted resting period; in these cases also the branching of tubes is more or less common, as appears in *Pinus* and the other cases above cited.

Another phase of the development at this stage which has not received sufficient attention is the effect of the pollen-tube itself on the formation of the fruit, or the effect in some cases of a mere irritation of the stigma. Gaertner[10] reports that with certain plants he was able to obtain sterile fruits as large as normal ones by applying to the stigmas the spores of *Lycopodium*. Tschermak[32] reports various cases in the enlargement of the ovary by the use of pollen which did not fertilize the seed. Massart[19] secured partial development of fruits in certain Cucurbitaceous forms by applying triturated pollen to the stigmas. In these cases no seeds were fertilized and it appears that the pollen is the seat of an excitant which penetrates the stigma and determines the survival of the ovary. Furthermore Leclerc du Sablon[28] has found that the crossing of melons and cucumbers results in a considerable modification of the quantity and quality of the carbohydrates in the placenta and the pericarp.

The *Cucurbitaceae* have long been under the observation of botanists, and certain features in the development of their fruit have frequently attracted attention. Soon after Amici's discovery of the pollen-tube of *Portulaca oleracea*[1] (1823), Brongniart[5] (1826) described a cellular conducting tissue in *Cucurbita maxima* Duch. and showed the pollen-tube traversing the beak of the nucellus. He observed that the "spermatic granules" were transported by a canal formed of the intercellular spaces of the tissues of the pistil.

Gaertner,[9] in 1827, made observations on a number of plants and reported an acid secretion from the stigma in certain cases at the time of maturity, and also a correlation between the amount of pollen on the stigma and the number of seeds produced, and that the number of seeds was increased by cross-fertilization.

Amici,[2] in 1830, in a letter to Mirbel states that the pollen-tube gradually elongates, descending through the style, and comes into contact with the ovule, each ovule being reached by a separate tube.

Schleiden[29] (1844) traced the pollen-tube through the micropyle and point of the nucellus, even to the embryo-sac, in *Pepo*, *Melo*, *Cucumis*, *Lagenaria* and *Momordica*, and in the case of *Momordica* saw the germinal nuclei emerge from the pollen-tube.

Recently Guéguen,[11] in his studies on the comparative anatomy of the conducting-tissues of style and stigma, examined, among the *Cucurbitaceae*, *Ecballium Elaterium*, *Cucurbita Pepo* and *Bryonia*. He found the stylar canal present in *Ecballium*, but obliterated in *Cucurbita*, but states that where the stigma is tetramerous the conducting-tissue presents an X-like structure as seen in transverse section of the style. This conducting-tissue he observed extended to the ovules, covering the surface of the placenta. He regards the *Cucurbitaceae* as very uniform in the matter of conducting-tissue.

In 1902 Longo[18] announced that the nutrition of the embryo in *Cucurbita* was performed by means of the pollen-tube. At the base of the neck of the nucellus the pollen-tube expands into a large bulla provided with branches which traverse the nucellus and the inner integument and proceed in intimate relation with the internal layers differentiated from the outer integument. Owing to a cutinization in the walls of the epidermal cells of the nucellus, as well as a suberization in the region of the chalaza, the embryo is soon cut off from the usual source of nutritive materials. The pollen-tube, with its branches rich in plasmatic contents and in starch, and with cellulose walls, furnishes the only points where fluids can enter the nucellus. Thus a haustorial function is ascribed to the pollen-tube, which draws upon the inner layers of the outer integument, itself nourished by the vascular bundles.

In the following year Longo[17] published the results of a more extended investigation, including thirteen genera and several more species. In all the cases examined the branching of the pollen-tube was found as a rule only in *Cucurbita*, though in all cases the course of the pollen-tube was always in accord with the distribution of conducting-tissue. The formation of the bulla at the base of the neck of the nucellus is correlated with the presence of

starch in the same neck. He found no expansion of the pollen-tube when the nucellus contained no starch; it forms simply a bulla without much branching (*Luffa maxima* Hort.) when the starch is normal, in very small grains; it forms a bulla with numerous branches (*Cucurbita*) when the starch is abundant in large grains, often in the form of amylo-dextrine. He concludes further that the course of the pollen-tube is regulated by particular substances which act in a chemotactic fashion; in this conclusion, agreeing with Lloyd.[16] When these substances are developed in the interior of the tissues it (the tube) has an endotropic course; when on the exterior an ectotropic course.

In an earlier article the writer made reference to the behavior of the pollen-tube in some of the *Cucurbitaceae*, and the phenomena observed in certain cases seemed worthy of further investigation. In most cases studied the pollen-tube presented no unusual conditions, but in a few instances the dilation or branching of the tube in the neck of the nucellus was a conspicuous feature. In *Cucurbita Pepo* the facts recorded by Longo were observed, and in other genera was noted a tendency similar, though less marked. The present study deals particularly with three members of the *Cucurbitaceae*, viz.: *Melothria pendula* L., *Micrampelis lobata* (Michx.) Greene, and *Cyclanthera explodens* Naud.

With a view to determining the length of time required for the pollen-tube to traverse the intervening tissue between the stigma and the embryo-sac, recourse was had to the following methods: Buds of the pistillate flowers about to open were covered with small bags of tissue paper tied about the peduncle. This was done usually between 4 and 6 o'clock P.M., and the flowers were usually found open the next morning. The stigmas were then pollinated and the bag replaced. At different intervals of time after pollination the fruits were collected and fixed in separate lots for study. Some were also examined fresh by means of freehand sections. In such preparations the pollen-tubes were easily recognized.

The effects of pollination were apparent soonest in the case of *Melothria*, in which the corolla-lobes close in over the stigma in a few hours. If pollination is not effected the flowers remain open for several days. In *Micrampelis* and *Cyclanthera* the results were

not immediately apparent, only those parts of the stigma upon which the pollen germinated showing any change. Under normal conditions the pistillate flowers of *Melothria* are pollinated early in the morning from staminate flowers which open the same day. The staminate flowers are very ephemeral and fall off usually in a few hours.

The effects of pollination and fertilization in the *Cucurbitaceae* have been carefully studied by Massart,[19] who experimented with *Cucurbita*, *Bryonia*, *Ecballium* and *Thladiantha*. He finds that the excitation which determines the survival and the beginning of the increase in the size of the fruit of *Cucurbita Pepo* is derived from the pollen itself and may be replaced by a traumatism; but that the excitation which provokes the general increase in the fruit proceeds only from fertilized ovules. The placentae, however, do not develop except in the vicinity of the fertilized ovules.

As to the time required for the pollen-tube to reach the embryo-sac, considerable variation was observed, the time varying twenty hours or more, depending on the number and position of the ovules. After twenty-six hours the pollen-tube was observed in the nucellus of *Melothria* and the same condition appeared in *Micrampelis* after nineteen hours from the time of pollination. In *Cyclanthera* no tubes were observed at the ovules until forty-one hours had elapsed. Most of the distance between the stigma and the embryo-sac is traversed by the pollen-tube in three or four hours. During this time the tube has passed through the style and into the ovary. The growth is much slower as the tube nears the micropyle. This feature seems to be correlated with the amount of available reserve food in the tube, which is of course greatest at the beginning of its growth.

In the *Cucurbitaceae* the form and structure of the ovary in different genera varies a good deal, but in most cases the cavity of the ovary is practically filled by the fleshy development of the placentae and the pericarp. A fusion of the ingrowing lobes of the placenta often occurs (*Cucurbita*, *Citrullus*) and leaves no space between them. In a similar way the stylar canal may also be obliterated. In *Melothria*, *Micrampelis* and *Cyclanthera*, however, such fusion does not take place before fertilization. The structure of the ovary in *Melothria* is similar to that of *Cucurbita*, except

that the ovules are arranged in one series instead of several on each flank of the three longitudinally-running placental lobes. Each of the placental lobes is covered with a single layer of cells, abounding in starch and possessed of denser plasmatic contents than those underneath. This layer also lines the narrow stylar canal, and covers the funicles of the ovules.

In *Micrampelis* the structure of the ovary is more complex. Here the normal ovary contains four ovules with their micropyles directed toward the pedicel. These are borne one on each flank of the two inwardly-growing placental lobes. In this case, however, the placental ridges become partially fused and grow downward toward the base of the ovary. In this genus as in *Melothria*, the cells which line the stylar canal and cover the placental lobes are filled with starch and denser protoplasm. Starch is also found in the underlying cells to a greater degree than in *Melothria*, but it is most abundant near the stylar canal and ovarian cavity.

Cyclanthera presents a condition in which there is one placental ridge in the ovary with a row of ovules on each flank. Here too the covering of the placenta and the lining of the stylar canal is similar to that of *Melothria* and *Micrampelis*. Both the epidermal covering of the placenta and that of the ovary-wall lying opposite (FIG. 14) are alike filled with starch, but those on the placenta are larger and more columnar in character. Here to a greater degree than occurs in the other cases the tissue beneath the epidermis is supplied with starch. Quite different from this is the condition found in *Cucurbita Pepo*, in which the conducting-tissue is devoid of starch. In *Cucurbita* the conducting-tissue consists of several layers of cells formed by the periclinal division of the epidermal cells covering the placentae.

The course of the pollen-tube in all cases under consideration is along the conducting-tissue just described. In *Melothria*, *Micrampelis* and *Cyclanthera* the tubes proceed down through the stylar canal and over the surface of the placentae. The tubes proceed upon the surface of the lobes wherever possible and not through them as a rule. In the restricted space of the style, where the canal offers insufficient space to accommodate many tubes, they traverse the surrounding tissues and break them down to a considerable extent. In such conditions, and elsewhere, where the

course of the tube lies through the tissues, it appears to travel through the intercellular spaces. The destruction of cells in its path seems to be due mostly to mechanical action and not to digestive enzymes, except in the nucellus of *Cyclanthera*. Fresh ovaries when teased apart showed the pollen-tubes in the stylar canal and passing over various parts of the placental surface. FIGURES 1 and 3–5 represent the course of the tube.

When the surfaces of the placentae are pressed together or against the ovary-wall, the space through which the tubes move is considerably restricted. Under such circumstances they crowd aside the cells of the conducting tissue (FIG. 11). Sometimes a tube may be seen to have passed under the conducting layer (FIG. 15). Where the tubes traverse the ovarian space in *Melothria* they sometimes develop transverse walls or plugs. The manner of their development appears to be the formation of a ring transversely which gradually narrows the aperture until it is completely closed. An excessive development in thickness of this wall sometimes follows, forming plugs as shown in FIGURE 2 *a*, *b*, *c*. Similar plugs have already been observed by Osterwalder[26] in *Aconitum Napellus*, and by others.

The pollen-tube proceeds by an approximately direct course to the micropyle, and passes down through the nucellus to the embryo-sac. In the apex of the nucellus it usually expands to several times its normal diameter in *Cyclanthera* (FIGS. 6, 13), and from this point sends down a straight and narrow tube to the embryo-sac. Sometimes the entire neck of the nucellus is destroyed by the dilation of the tube. This expansion of the pollen-tube in the apex of the nucellus occurs frequently in *Melothria*, though it was never observed to reach the same proportions as in *Cyclanthera*. In *Micrampelis* also such conditions were sometimes observed; here, however, they are not the rule but the exception. In such cases, both in *Melothria* and *Cyclanthera*, the contiguous cells were destroyed.

That such dilations of the pollen-tube are directly correlated with the occurrence of starch in the surrounding tissues is maintained by Longo, as above pointed out; but the behavior of the pollen-tube of *Elodea*, as described by Wylie,[33] indicates that such conditions are not always the cause of the enlargments of the tube,

for in this case they occur in the ovarian cavity. This has already been suggested by Lloyd[16] in discussing the pollen-tube in the *Cucurbitaceae* and *Rubiaceae*.

In the plants here under consideration the nucellus is practically devoid of starch, which is abundant in the integuments of *Micrampelis* and *Cyclanthera*, though not so abundant in *Melothria*.

The anatomical character of the conducting-tissue is a feature of some interest. In all cases examined a continuous conducting-tissue reaches from the stigma to the micropyle. In *Micrampelis* the neck of the nucellus pushes through the micropyle, and comes out even with the top of the integuments. Practically the same conditions exist in *Cyclanthera*, but in *Melothria* the apex of the nucellus is usually overtopped by the integuments. In the three genera just mentioned the conducting-tissue consists of a single layer of cells, the epidermis covering the placentae and lining the stylar canal. This layer appears to be the only one serving directly as conducting-tissue. On the stigma the starch is restricted to the subepidermal tissue, none appearing in the more densely plasmatic cells of the epidermis. The glandular character of the epidermal cells is quite apparent both on the stigma and in the interior (FIGS. 9, 11, 14). In the interior the cells in the path of the pollen-tubes show indications of activity, by the dense aggregation of the cytoplasm next the exposed side and surrounding large and conspicuous nuclei.

Considerable effort has been made to determine the directive force controlling the movements of the pollen-tube. We may note in passing that Nawaschin,[24] Zinger[34] and some others have interpreted the endotropic and ectotropic behavior of pollen-tubes as of phylogenetic significance. But evidence at present available seems to point to physiological processes and mechanical relations as the determining factors. In favor of this view we may cite the anatomical evidence contributed by Lloyd[15] in the *Rubiaceae*, Longo[17] on the *Cucurbitaceae*, and the observations of Capus[6] and of Guéguen,[11] and the results of the experimental studies of Miyoshi[20], [21] and others. Molisch[22] has shown that pollen-tubes are positively chemotropic and some negatively aerotropic. Miyoshi sowed pollen-grains on agar in which were imbedded pieces of stigma, ovary, and ovules of different degrees of development. Tne pollen-tubes

grew toward the pieces from the vicinity of the stigma and were most strongly attracted by ovules ready for fertilization, growing into the micropyle in each case. He concludes that this stimulant is in the nature of a fluid, and in another article has shown that pollen-tubes grow into the stomata of *Tradescantia* leaves, the intercellular spaces of which have been filled with sugar solution. That the pollen-tube is also directed mechanically in its course is maintained by Miyoshi, and Capus states that the mechanical rôle of the conducting-tissue consists in placing the pollen-tube in relation with the micropyle, and that its economy and simplicity depend on the structure of the ovary.

That the stimulants which direct the pollen-tube are nutritive in character is quite evident. Dalmer[8] states that pollen-tubes are nourished by amyloid substances secreted by stigma, stylar canal, and the interior of the ovary, though he maintains that the entrance of the pollen-tube into the ovule is a purely mechanical phenomenon. Miyoshi points out that sugar as a stimulant can operate only extra-cellularly, and it is plain that where the course of the pollen-tube is intercellular or through the locular space of the ovary that its growth must be at the expense either of the reserve materials within the tube or of substances elaborated by the tissues in its path. The cytological features of the conducting-tissues of the *Cucurbitaceae* here under consideration are similar to those of certain nectaries in the abundance of starch and quantity of cytoplasm, appearance of molecular structures, etc. The evidence here points to the secretion of carbohydrates (probably sugar) as the nutritive material. That the pollen-tubes are partial to the more glandular cells is indicated in *Cyclanthera*. In this case the ovary sometimes shows a considerable locular space at the time of the entrance of the pollen-tubes. The epidermal cells of the placenta are larger and more glandular in appearance than those of the ovary-wall opposite. Though their distance apart is not great, the pollen-tubes always cling to the placenta instead of to the opposite wall, though that likewise is supplied with starch.

One noticeable feature of the relation between pollen-tube and conducting-tissue in *Melothria*, *Micrampelis* and *Cyclanthera* is the fact that while starch is abundant in the conducting-tissue, none appears in the tube. In *Cucurbita Pepo* on the other hand the condi-

tions are reversed, and starch is entirely absent from the ample conducting-tissue, though abundant in the pollen-tube almost to the time of its entrance into the embryo-sac. These facts are regarded as evidence that the directive stimulant, in these cases at least, is of a different character from the substances in the tube. It is, however, recognized that the absence of starch from the cells of the conducting-tissue may not mean an absence of soluble carbohydrates, for no starch is visible in the secreting cells of some nectaries. The application of iodine to sections of the style and ovary of *Cucurbita* easily brings out the pollen-tubes in contrast with the conducting-tissue, the former rich in starch, coloring a dark blue, the latter a deep yellow, indicating an abundance of albuminous material. The pollen-tube branches in the nucellus according to the disposition of starch, as above cited in reference to Longo's work.

If the growth of the pollen-tube or its branches is thus regulated by the occurrence or distribution of nutritive material, we have apparently an explanation for the growth of the tube through the nucellus to the embryo-sac, structures which, in the cases here considered, are normally filled with starch before the approach of the pollen-tube.

At what distance from the ovule the pollen-tube comes under its influence, has not in these cases been determined, but it is evident that the embryo-sac is the source of a stimulant of some sort by which the pollen-tube is directed unerringly toward it. As to the character of this stimulant the evidence is meager, but what there is seems to indicate a sugar.

Miyoshi's results with the pollen of *Digitalis* and numerous other plants show that their tubes are sensitive to the presence of certain soluble carbohydrates, but are indifferent to or repelled by a variety of other substances. Moreover, the fact cited elsewhere by the same author to the effect that the pollen-tubes of distantly related plants were attracted to the same ovule and to different ovules would indicate that the stimulant is some substance quite common in plant tissues.

It is suggested here that a difference in the degree of concentration of such a solution as a sugar may be a sufficient factor in directing the pollen-tube. This is in accord with the observations of Miyoshi and others.

As to the particular organ of the embryo-sac responsible for the discharge of the stimulant, opinions have differed, some ascribing that function to the synergids and others to the egg-cell (Strasburger[31], Lloyd[15]). But to the writer it seems more probable that the source of such a stimulant may be found in the endosperm-nucleus and its cytoplasm. The appearance of this nucleus, indicating the large degree of activity, and its abundant cytoplasm filled with starch would favor such a view. The pollen-tube is presumably ruptured upon entering the embryo-sac by the rapid absorption of water and consequent increased turgor, and its contents discharged into the male generative nuclei come under the influence of the egg-cell and fertilization takes place, and in some cases also the fusion with the endosperm-nucleus.

SUMMARY AND CONCLUSIONS

1. The behavior of the pollen-tube was studied in *Melothria pendula*, *Micrampelis lobata*, and *Cyclanthera explodens*. As observed in these cases the time elapsing between pollination and the arrival of the pollen-tube at the embryo-sac was twenty-six hours in *Melothria*, nineteen hours in *Micrampelis*, and in *Cyclanthera* forty-one.

2. The pollen-tube follows conducting-tissue which for the most part is formed of the epidermis lining the stylar canal and covering the placental lobes. The tube traverses this tissue by passing over its surface wherever possible, and rarely affects the cells injuriously. The conducting-tissue of these plants is abundantly supplied with starch. In *Cucurbita Pepo* starch is wanting in the conducting-tissue but present in abundance in the pollen-tube. In all cases observed where starch abounded in the conducting-tissue it was absent from the pollen-tube. The pollen-tube appears to be directed by nutritive substances secreted by the conducting-tissue. Attention is called to the similarity in anatomical features of the cells of the conducting-tissue to those of certain nectaries, as evidence as to the nature of the secretion.

3. It is thought that the pollen-tube comes under the influence of a stronger stimulant emanating from the ovule. It is suggested that the source of this stimulus may be the endosperm-nucleus.

4. The evidence at hand supports the contention of Miyoshi and others that the behavior of the pollen-tube is a phenomenon

of chemotropism as against its being due to mechanical conditions or of phylogenetic significance.

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Description of plates 16 and 17

PLATE 16

1. Diagrammatic figure representing longitudinal section through gynoecium of *Melothria*. Course of pollen-tube (*P. t.*) intercellular.

2. *a*, *b*, *c*. Pollen-tube showing plugs.

3. Longitudinal section through gynoecium of *Micrampelis*. Conducting-tissue shaded.

4. Ovary of same at right angles to figure 3.

5. Longitudinal section through ovary of *Cyclanthera*, showing path of pollen-tubes.

6. Diagram of micropylar region of ovule of *Cyclanthera*, showing dilation of pollen-tube, *P. t.*

7. Ditto, *Melothria*.

8. Ditto, *Micrampelis*.

PLATE 17

9. Conducting-tissue of *Melothria* on placental folds. Pollen-tube in transverse section. × 440.

10. Conducting-tissue on funicle of ovule of *Melo hria*. × 440.

11. Conducting-tissue of *Micrampelis*. Transverse section of pollen-tube. × 440.

12, 13. Transverse section through neck of nucellus, in *Cyclanthera*, before and after passage of pollen-tube, *P. t.* × 440.

14. Conducting-tissue in ovary of *Cyclanthera*. *Pl.*, placenta; *o. w.*, ovary-wall; *P. t.*, part of pollen-tube. × 440.

15. Same showing pollen-tube (*P. t.*) passing under some cells of conducting-tissue. × 440.

New England desmids of the sub-family Saccodermae

Joseph Augustine Cushman

The sub-family *Saccodermae* contains many of the least conspicuous of the desmids and also as a rule those which are apt to be overlooked, as is shown by the fact that previous to the writer's work on the New England species there were but fourteen species and varieties known from New England. In the present paper twenty-seven species and varieties are noted, for all of which New England specimens have been seen by the writer. While this doubles the number previously known, it is small when compared with the number known in the British Isles, fifty-seven species and varieties being recorded by W. & G. S. West in their recent monograph. In the genus *Spirotaenia* for instance, there are fourteen species recorded by the Wests from the British Isles, while from New England there are three (one up to the time of the present paper). This difference will probably be somewhat lessened with further collecting, especially in the White Mountain region where conditions are very favorable for certain forms.

In the preparation of the present paper material was examined from all of the New England states and such of the material of previous writers as is available. Material from Vermont and Connecticut has however been disappointing and not in any quantity. All the localities from which actual specimens have been seen by the writer are indicated by an exclamation point. Recent work has shown errors in the previous work and so far as known these are indicated in the brief synonymy given. The generic position is much changed from that in Wolle's Desmids of the United States, and his references are given whenever he has recorded the particular species. The forms new to the New England flora are marked by an asterisk.

In most points the monograph of the Wests has been followed. Free use has been made of their keys where they are given. At the end of the present paper is given a simple key to the New

England genera and species. While this is based upon the New England species actually seen, it nevertheless will largely apply to the northeastern United States.

Tribe GONATOZYGAE

GONATOZYGON DeBary. 1856

1. GONATOZYGON MONOTAENIUM DeBary, in Rabenh. Alg. *539*. 1856. — *G. Ralfsii* DeBary, Conj. 76. *pl. 4. f. 23–25*. 1858. — *G. asperum* Wolle, Desm. U. S. 22. *pl. 1. f. 1*. 1884.

Cells cylindrical, the apices slightly dilated; cell-wall usually with spinose granules.

Length 240–260 μ: breadth 10–22 μ.

Me.: (*W. West*). N. H.: Pudding pond, North Conway, rare! Holderness, scarce (*Wests*). Mass.: Carver's Pond, Bridgewater!

* **Gonatozygon monotaenium minutum** var. nov.

Variety very much smaller than the typical form of the species; other characters like the typical.

Length 59–68 μ: breadth in middle 6 μ: apices 7 μ.

Mass.: Winchester Reservoir, frequent (F. S. Collins Coll., Oct. 9, 1905)!

2. GONATOZYGON BRÉBISSONII DeBary, Conj. 77. *pl. 4. f. 26, 27*. 1858. — *G. asperum* Johnson, Bull. Torrey Club **22**: 291. *pl. 239. f. 8*. 1895.

Cells narrowly cylindric-subfusiform, the poles subcapitate; cell-wall densely granulate.

Length 112–160 μ: breadth 6–8 μ: apices 5.5–7 μ.

Me.: Scarbro' (*W. West*). N. H.: Laconia (*Wests*). Mass.: Reading!

3. GONATOZYGON PILOSUM Wolle, Bull. Torrey Club **9**: 27. *pl. 13. f. 16*. 1882. — Desm. U. S. 32. *pl. 1. f. 2*. 1884.

Cells elongate, cylindrical, usually not dilated at the apices; cell-wall clothed with small, straight, hair-like spines.

Length 390 μ: breadth 12.5 μ.

Mass.: Pondville! Conn.: Lamp Mortar Rock, Fairfield (*Wests*).

4. GONATOZYGON ACULEATUM Hastings, Am. Month. Micr. Jour. **13**: 29. 1892.

Cells cylindrical, the apices not at all or very slightly dilated; cell-wall clothed with long stiff spines.

Length 350 μ: breadth with spines 40 μ: without spines 20 μ.

N. H.: Pennichuck Pond, Nashua (*Hastings*). Meredith, occasional (*Johnson*). Laconia, frequent (*Wests*). Mass.: Plainville!

Tribe SPIROTAENIEAE

SPIROTAENIA Bréb. 1848

5. SPIROTAENIA CONDENSATA Bréb. in Ralfs, Brit. Desm. 179. *pl. 34. f. 1.* 1848. — Wolle, Desm. U. S. 33. *pl. 3. f. 21, 22.* 1884.

Cells cylindrical, the ends rounded, the length 7–10 times the width; a single broad, parietal, revolving chloroplast with eight to ten close revolutions.

Length 108–160 μ: breadth 15–20 μ.

Me.: Orono (*Harvey*). N. H.: Pudding Pond, North Conway! Mass.: South Framingham! Carver's Pond, Bridgewater! Gay Head, Marthas Vineyard! R. I.: Wainskut Pond, North Providence (*Bailey*). Conn.: Mill River, Fairfield (*Wests*).

* 6. SPIROTAENIA PARVULA Arch. Proc. Dubl. Nat. Hist. Soc. 3^2: 84. *pl. 2. f. 32–43.* 1863.

Cells small, the ends somewhat truncately rounded, 5–6 times as long as wide; a single very narrow chloroplast with slightly more than a single revolution.

Length 23 μ: breadth 4 μ.

Mass.: North Watuppa Lake, Fall River! New to North America.

* 7. **Spirotaenia obscura crassum** var. nov.

Cells fusiform, attenuated toward the poles, the apices rounded; chloroplast axile, cristate, with several ridges, making about one revolution: variety much smaller and comparatively shorter than the typical form.

Length 24 μ: breadth 10 μ.

Mass: South Framingham (May 1904)!

MESOTAENIUM Näg. 1849

* 8. MESOTAENIUM DEGREYI BREVE West, Jour. Linn. Soc. Bot. **29**: 131. *pl. 20. f. 6.* 1892.

Cells straight or slightly curved, 2½–3 times as long as wide. Length 58–66 μ: breadth 21–22 μ.

Mass.: Sphagnum material, North Watuppa Lake, Fall River (collected by S. N. F. Sanford, July 5, 1905)! New to North America.

9. MESOTAENIUM MACROCOCCUM (Kütz.) Roy & Bisset. *Palmogloea macrococca* Kütz. Phyc. Germ. 153. 1845. — *Mesotaenium macrococcum* Roy & Bisset, Ann. Scott. Nat. Hist. 1894. — *M. Braunii* Wolle, Desm. U. S. 31. *pl. 3. f. 5–9.* 1884.

Cells cylindrical, twice as long as wide, the apices truncately rounded; chloroplast an axile plate.

Length 38 μ: breadth 18 μ.

N. H.: From the Flume (*F. S. Collins*). Mass.: Lake Quinsigamond, Worcester (*Stone*). Gibb's Pond, Nantucket!

MESOTAENIUM MACROCOCCUM MICROCOCCUM (Kütz.) W. & G. S. West. *Palmogloea micrococca* Kütz. Bot. Zeitung **5**: 221. 1847. — *Mesotaenium micrococcum* Wolle, Desm. U. S. 32. *pl. 3. f. 10.* 1884. — *M. macrococcum micrococcum* W. & G. S. West, Bot. Trans. Yorks. Nat. Union **5**: 41. 1901.

Cells cylindrical, usually less than twice as long as wide, the apices rounded, slightly narrowed.

Length 15 μ: breadth 8.5 μ.

Mass.: Lake Quinsigamond, Worcester (*Stone*). Sandwich!

* 10. MESOTAENIUM CHLAMYDOSPORUM DeBary, Conj. 75. *pl. 7D.* 1858.

Cells oblong-cylindrical, 2-2½ times as long as wide, the apices broadly rounded; chloroplast a narrow axile plate.

Length 25 μ: breadth 11 μ.

Mass.: North Lake Watuppa, Fall River! New to the United States.

* MESOTAENIUM CHLAMYDOSPORUM MINOR W. &. G. S. West, Brit. Desm. **1**: 53. 1904.

Smaller than the typical form.

Length 18.5–21 μ: breadth 6.5–8.5 μ.

Mass.: South Framingham!

* 11. **Mesotaenium minimum** sp. nov.

Cells minute, 3 times as long as wide, the apices broadly rounded, imbedded in mucous masses; chloroplast an axile plate.

Length 14 μ: breadth 4.5 μ.

R. I.: Nyatt! (Collected by S. N. F. Sanford, July 2, 1905).

12. MESOTAENIUM ENDLICHERIANUM Näg. Gatt. Einzell. Algen 109. *pl. 6B.* 1849. — Wolle, Desm. U. S. 32. *pl. 3. f. 11.* 1884.

Cells cylindrical, about three times as long as wide, the apices broadly rounded; cells free-swimming; chloroplast an axile plate.

Length 25–31: breadth 8–10 μ.

N. H.: Intervale, frequent! Mass.: Lake Quinsigamond, Worcester (*Stone*). North Lake Watuppa, Fall River! Swansea!

CYLINDROCYSTIS Menegh. 1838

13. CYLINDROCYSTIS BRÉBISSONII Menegh. Accad. Sci. Torino, Mat. e Fis. II. **5**: 89. *pl. 12. f. 13.* 1843.—*Penium Brébissonii* Wolle, Desm. U. S. 36. *pl. 5. f. 7, 8.* 1884.

Cells cylindrical, 2½–3 times as long as wide, the apices rounded; chloroplast stellate with few large radiating processes.

Length 50–62 μ: breadth 17–18 μ.

Me.: Along Penobscot River, near Orono (*Harvey*). Mass.: Amherst (*W. West*). West Bridgewater! Tom Never's Pond, Nantucket!

CYLINDROCYSTIS BRÉBISSONII MINOR W. & G. S. West, Trans. Roy. Irish Acad. **32B**[1]: 20. *pl. 2. f, 7.* 1902.

Cells narrower and shorter than the typical form.

Length 28–32 μ: breadth 12–13 μ.

N. H.: Intervale! Mass.: Westport! Great Miox's Pond, Nantucket!

14. CYLINDROCYSTIS CRASSA DeBary, Conj. 37. 74. *pl. 7. f. C. 1–12.* 1828.—*Penium crassa* Wolle, Desm. U. S. 37. *pl. 5. f. 3.* 1884.

Cells oblong-cylindrical, twice as long as wide; chloroplast as in *C. Brébissonii.*

Length 40 μ: breadth 20 μ.

Me.: Orono (*W. West*). N. H.: Mt. Moosilauke! Mass.: Amherst (*W. West*).

15. CYLINDROCYSTIS AMERICANA MINOR Cushman, Rhodora **7**: 113. 1905.

Cells cylindrical, twice as long as wide, with broadly rounded apices, and a slight median constriction; each cell with a stellate chloroplast, smaller than the typical form.

Length 32–34 μ: breadth 16 μ.

N. H.: Mt. Moosilauke! Mass.: Sandwich!

16. CYLINDROCYSTIS DIPLOSPORA Lund. Nova Acta Reg. Soc. Sci. Upsala III. **8**: 83. *pl. 5. f. 7.* 1871.—*Calocylindrus diplospora* Wolle, Bull. Torrey Club **9**: 15. 1882.—Desm. U. S. 56. *pl. 12. f. 18.* 1884.

Cells subcylindrical, twice as long as wide, slightly broader toward the truncately rounded apices; chloroplasts with numerous radiating processes.

Length 60–61 μ: breadth 31–32 μ: isthmus 27–28 μ.

N. H.: Intervale! Mass.: Mt. Everett (*Wolle*).

* **Cylindrocystis diplospora minor** var. nov.

Cells like the typical but very much smaller.

Length 35–38 μ: breadth 16–18 μ: isthmus 14–15.5 μ.

Mass.: North Lake Watuppa, Fall River!

NETRIUM Näg. 1849

17. NETRIUM DIGITUS (Ehrenb.) Itzigs. & Rothe. *Closterium Digitus* Ehrenb. Phys. Abh. Akad. Wiss. Berlin **1830**: 68. 1832.—*Penium Digitus* Wolle, Desm. U. S. 34. *pl. 53. f. 1.* 1884.—*Netrium Digitus* Itzigs. & Rothe, in Rabenh. Alg. *508.* 1856.—*Penium lamellosum* Wolle, Desm. U. S. 34. *pl. 5. f. 4.* 1884.

Cells elliptical-oblong, gradually attenuated toward the apices which are rounded-truncate, three to four times as long as wide; chloroplasts axile with about six longitudinal plates, deeply notched at the outer margins.

Length 105–430 μ: breadth 34–105 μ: apices 14–45 μ.

Me.: Oldtown and Great Works (*Harvey*). Kittery, frequent! Bridgeton! N. H.: Saco Lake (*Wood*). Mt. Moosilauke, abundant! Pudding Pond, North Conway! Intervale! Mass.: Lake Quinsigamond, Worcester (*Stone*). Amherst (*W. West*). Tewksbury (*Lagerheim*)! Winchester Reservoir! Reading! Wellesley! Pondville! Plainville! Bridgewater! Halifax! Swansea! Fall River!

Sandwich! Marthas Vineyard! Nantucket! R. I.: Nyatt! Portsmouth! Wainskut Pond, North Providence (*Bailey*). Conn.: Bridgeport!

This seems to be the most abundant and widely distributed of the New England desmids, a representative gathering which does not include it being the exception. Its size is extremely variable as shown above.

*18. NETRIUM NAEGELII (Bréb.) W. & G. S. West. *Penium Naegelii* Bréb. in Pritchard, Infusoria 751. 1861. — *Netrium Nägelii* W. & G. S. West, Brit. Desm. **1**: 66. *pl. 7. f. 4, 5.* 1904.

Cells oblong-lanceolate, 4–5 times as long as wide, the apices truncately rounded; chloroplasts as in the preceding species.

Length 100–150 μ: breadth 24–28 μ.

Mass.: Plainville! North Watuppa Lake, Fall River!

This species, although a very cosmopolitan one, has not previously been reported from North America.

19. NETRIUM OBLONGUM (DeBary) Lütkem. *Penium oblongum* DeBary, Conj. 42, 73. *pl. 7G. f. 1. 2.* 1858. — *Netrium oblongum* Lütkem. Beitr. Biol. Pfl. **8**: 407. 1902.

Cells oblong-cylindrical, 3–3½ times as long as wide, the apices rounded; chloroplasts of the usual type, with six longitudinal plates.

Length 96 μ: breadth 29 μ.

N. H.: Intervale! Mass.: Amherst (*W. West*).

Wolle's figure of *Penium oblongum* is not this species, but represents a *Mesotaenium*, possibly *M. DeGreyi* Turn.

NETRIUM OBLONGUM CYLINDRICUM W. & G. S. West, Jour. Bot. **41**: 40. *pl. 446. f. 10.* 1903.

"Cells smaller than in the typical form and exactly cylindrical: apices hemispherical."

Length 60–71 μ: breadth 18–22 μ.

N. H.: Mt. Moosilauke!

NETRIUM OBLONGUM f. MAJOR (Turn.) Cushman, Rhodora **7**: 113. 1905.

Cells much larger than in the typical form of the species.

Length 168 μ: breadth 44 μ.

N. H.: Pudding Pond, North Conway!

20. NETRIUM INTERRUPTUM (Bréb.) Lütkem. *Penium interruptum* Bréb. in Ralfs, Brit. Desm. 151. *pl. 25. f. 4.* 1848. — Wolle, Desm. U. S. 35. *pl. 5. f. 14, 15.* 1884. — *Netrium interruptum* Lütkem. Beitr. Biol. Pfl. **8**: 407. 1902.

Cells cylindrical, rapidly attenuate toward the obtusely rounded apices; chloroplasts four, two in each semicell, proximal ones in each semicell cylindrical, distal ones conical, each with eight longitudinal plates, the free margins of which are entire.

Length 172–320 μ: breadth 38–40 μ.

Me.: Oldtown and Great Works (*Harvey*). N. H.: Intervale! Mass.: Lake Quinsigamond, Worcester (*Stone*). Pondville! Bridgewater!

Key to the New England genera and species of Saccodermae

SACCODERMAE: Cell-wall unsegmented, without pores; point of division of cells not fixed, and unknown previous to the actual division.

Cells elongate, cylindrical, unconstricted in the middle, forming loose filaments; cell-wall granular or spinose; chloroplasts axile. (GONATOZYGAE.)
1. GONATOZYGON.

Cells solitary, relatively short and mostly unconstricted. (SPIROTAENIEAE.)

One chloroplast in each cell.

Chloroplast spirally twisted. 2. SPIROTAENIA.

Chloroplast plane, axile. 3. MESOTAENIUM.

Two chloroplasts (occasionally four) in each cell.

Chloroplasts star-shaped, radiating from a central pyrenoid. 4. CYLINDROCYSTIS.

Chloroplasts with longitudinal ridges, the edges of which are usually notched. 5. NETRIUM.

1. GONATOZYGON

Cell-wall densely granulate.

Cells cylindrical, the apices slightly dilated. 1. *G. monotaenium.*

Cells cylindrical-subfusiform, the apices subcapitate. 2. *G. Brébissonii.*

Cell-wall with small, short, straight, hair-like spines; cells not dilated at the apices. 3. *G. pilosum.*

Cell-wall with long, stiff, fairly stout spines. 4. *G. aculeatum.*

2. SPIROTAENIA

Chloroplast parietal, band-like.

Cells large, cylindrical; chloroplast broad, making 8–10 close revolutions. 5. *S. condensata.*

Cells minute, fusiform; chloroplast narrow, making about a single revolution. 6. *S. parvula.*

Chloroplast axile, cristate, with several ridges, making about a single revolution. 7. *S. obscura.*

3. MESOTAENIUM

Cells imbedded in mucilaginous masses.
- Cells large, often curved, 2½–3 times as long as wide, diameter 20 μ or more. 8. *M. DeGreyi.*
- Cells small, cylindrical, twice as long as wide, diameter 16–18 μ. 9. *M. macrococcum.*
- Cells small, cylindrical, 2–2½ times as long as wide, diameter 11–12 μ. 10. *M. chlamydosporum.*
- Cells minute, cylindrical, 3 times as long as wide, diameter 4–5 μ. 11. *M. minimum.*

Cells free-swimming, about 3 times as long as wide, the breadth 8–10 μ. 12. *M. Endlicherianum.*

4. CYLINDROCYSTIS

Cells unconstricted.
- Cells cylindrical, 2½–3 times as long as wide. 13. *C. Brèbissonii.*
- Cells oblong-cylindrical, 1½–2 times as long as wide. 14. *C. crassa.*

Cells very slightly constricted.
- Cells slightly dilated toward the apices, which are truncately rounded. 15. *C. diplospora.*
- Cells not dilated toward the apices, which are broadly rounded. 16. *C. americana.*

5. NETRIUM

Cells with 2 chloroplasts, the edges notched.
- Cells elliptical-oblong, large, 3–4 times as long as wide, diameter usually more than 40 μ. 17. *N. Digitus*
- Cells oblong-lanceolate, of medium size, 4–5 times as long as wide, diameter usually about 30 μ. 18. *N. Naegelii.*
- Cells oblong-cylindrical, of medium size, 3–3½ times as long as wide, diameter usually about 30 μ. 19. *N. oblongum.*

Cells with 4 chloroplasts, the edges entire; ends of cells rapidly attenuated. 20. *N. interruptum.*

BOSTON SOCIETY OF NATURAL HISTORY.

INDEX TO AMERICAN BOTANICAL LITERATURE
(1906)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in its broadest sense.

Reviews, and papers which relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions their kindness will be appreciated.

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Rubus floricomus sp. nov.

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Rubus Groutianus sp. nov.

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Includes descriptions of new species in *Marsilea*, *Dondia*, *Cassia*, *Maytenus*, *Myroxylon*, *Opuntia*, *Limnanthemum*, *Metastelma* and *Aster*.

Brumhard, P. *Erodii* generis novae varietates atque formae. Repert. Nov. Sp. **2**: 116–119. 1 Ap 1906.
Includes a description of *E. Botrys* f. *montanum* forma nova, from California and Chile.

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Descriptions and illustrations of 84 species, of which 58 are described as new.

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Claassen, E. Key to the species of liverworts recognized in the sixth edition of Gray's Manual of Botany. Ohio Nat. **6**: 530–540. 14 My 1906.

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Includes descriptions of 6 new species in as many genera.

Copeland, E. B. On the water relations of the cocoanut palm (*Cocos nucifera*). Philipp. Jour. Sci. **1**: 6–57. *f. 1–20.* Ja 1906.

Davenport, G. E. *Botrychium matricariaefolium* A. Br. An enquiry into the relationships between *Botrychium neglectum* Wood, *Botrychium matricariaefolium* A. Braun, and *Botrychium ramosum* Ascherson. Fern Bull. **14**: 11–19. *pl. 1, 2.* [Mr] 1906.

DeVries, H. Personal impressions of Luther Burbank. The Independent **60**: 1134–1140. 17 My 1906. [Illust.]

Diels, L. *Anonaceae* andinae. Bot. Jahrb. **37**: 408–410. 24 Ap 1906.
Descriptions of new species, from Peru, in *Guatteria* (2), *Aberemoa*, and *Oxandra*.

Diels, L. *Basellacea* nova peruviana. Bot. Jahrb. **37**: 400. 24 Ap 1906.
Boussingaultia minor sp. nov.

Diels, L. *Commelinaceae* andinae. Bot. Jahrb. **37**: 381, 382. 24 Ap 1906.
Descriptions of 2 new species in *Tradescantia* from Peru.

Diels, L. *Crassulaceae* andinae. Bot. Jahrb. **37**: 410–412. 24 Ap 1906.
Descriptions of 6 new species in *Cotyledon* from Peru.

Diels, L. *Cunoniaceae* andinae. Bot. Jahrb. **37**: 412–416. 24 Ap 1906.
Descriptions of 10 new species and a variety ("n. sp.") in *Weinmannia*.

Diels, L. *Juglans* in Peruvia amazonica collecta. Bot. Jahrb. **37**: 398. 24 Ap 1906.
J. neotropica sp. nov.

Diels, L. *Oxalidaceae* andinae. Bot. Jahrb. **37**: 423–427. 24 Ap 1906.

Descriptions of 12 new species in *Oxalis* from Peru.

Diels, L. *Portulacaceae* andinae. Bot. Jahrb. **37**: 399, 400. 24 Ap 1906.

Descriptions of 3 new species in *Calandrinia* from Peru.

Diels, L. *Saxifragaceae*: *Escallonia* nova andina. Bot. Jahrb. **37**: 412. 24 Ap 1906.

E. hypsophila sp. nov., native of Peru.

Diels, L. *Scrophulariaceae* andinae (*Calceolariis* exceptis). Bot. Jahrb. **37**: 427–433. 24 Ap 1906.

New species are described in *Alonsoa*, *Linaria*, *Sibthorpia*, *Ourisia*, *Gerardia* (4), *Buechnera*, and *Bartsia* (11).

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Dobbin, F. Insect galls. Am. Bot. **9**: 85–87. [My 1906.]

Domin, K. Some new South American species of *Koeleria*. Repert. Sp. Nov. **2**: 88–94. 20 Mr 1906.

Descriptions of 3 new species and several new varieties are included.

Dukes, W. C. An Alabama station for *Botrychium biternatum*. Fern Bull. **14**: 45, 46. Ap 1906.

Durand, E. J. Sporangial trichomes. Fern Bull. **14**: 20, 11. [Mr] 1906.

Edwards, A. M. On a deposit of *Bacillaria* from Texas and New Mexico. Nuova Notar. **17**: 61–69. Ap 1906.

Fedde, F. *Eschscholtziae* generis species novae. I. Repert. Sp. Nov. **3**: 145–148. 1 My 1906.

Descriptions of 3 new species and several new varieties, all from California and Nevada.

Fink, B. Edward Tuckerman — a brief summary of his work. Bryologist **9**: 1, 2. *pl. 1* (= *portrait*). 2 Ja 1906.

Fink, B. Further notes on cladonias. VI. Bryologist **9**: 21–24. 3 Mr 1906. [Illust.]

Fischer, W. Ecological observations on the flora of the shale bluffs in the vicinity of Columbus, Ohio. Ohio Nat. **6**: 499–503. *f. 1, 2.* 14 Ap 1906.

Fischer, W. New and rare Ohio plants. Ohio Nat. **6**: 475, 476. 15 F 1906.

Foslie, M. & Howe, M. A. New American coralline algae. Bull. N. Y. Bot. Gard. **4**: 128–136. *pl. 80–93.* 17 Mr 1906.

New species and varieties are described and figured in *Archaeolithothamnion*, *Lithothamnion* (2), *Goniolithon* (3), and *Lithophyllum* (5).

Freeman, E. M. The affinities of the fungus of *Lolium temulentum* L. Ann. Myc. **4**: 32–34. 5 Ap 1906.

Gilbert, B. D. *Polypodium vulgare* and its varieties in America. Fern Bull. **14**: 33–41. Ap 1906.

Gilg, E. Beiträge zur Kenntnis der *Gentianaceae* III. *Gentianaceae* andinae. Repert. Nov. Sp. **2**: 33–56. 15 F 1906.

New species are described in *Erythraea*, *Gentiana* (33), *Halenia* (3), *Macrocarpaea* (2), *Chelonanthus* (2), and *Symbolanthus* (3).

Gleason, H. A. A revision of the North American *Vernonieae*. Bull. N. Y. Bot. Gard. **4**: 144–243. 4 Je 1906.

Recognizes 143 species in 17 genera; many described as new.

Goebel, K. Wilhelm Hofmeister. Plant World **8**: 291–298. *portrait*. [Ja 1906.]

Goodale, G. L. A new form of "container" for use in museums of economic botany. Am. Jour. Sci. IV. **21**: 451, 452. Je 1906.

Graebner, P. *Caprifoliaceae* andinae. Bot. Jahrb. **37**: 433–436. 24 Ap 1906.

Includes descriptions of 6 new species in *Viburnum*.

Graebner, P. Die Gattungen der natürlichen Familie der *Valerianaceae*. Bot. Jahrb. **37**: 463–480. 24 Ap 1906.

Graebner, P. *Valerianaceae* andinae. Bot. Jahrb. **27**: 436–451. 24 Ap 1906.

New species are described in *Valeriana* (29—one from Mexico), *Aretiastrum*, and *Stangea* gen. nov. (5); also the new genus *Belonanthus*.

Greene, E. L. Certain malvaceous types. Leaflets **1**: 205–209. 10 Ap 1906.

Four new genera, *Iliamna*, *Malacothamnus*, *Eremalche*, and *Disella*; a new species in the first of these.

Greene, E. L. A further study of *Chaptalia*. Leaflets **1**: 190–197. 24 F 1906.

With descriptions of 18 new species.

Greene, E. L. The genus *Bossekia*. Leaflets **1**: 210, 211. 10 Ap 1906.

A Neckerian name, here substituted for *Rubacer* Rydb.

Greene, E. L. The genus *Nuttallia*. Leaflets **1**: 209, 210. 10 Ap 1906.

Nuttallia Raf. 1818.

Greene, E. L. The genus *Tridophyllum*. Leaflets **1**: 188, 189. 24 F 1906.

Tridophyllum Necker.

Greene, E. L. *Icianthus* and *Sprengeria*. Leaflets **1**: 197–199. 24 F 1906.
Two new genera (with 3 new species) of *Cruciferae*.

Greene, E. L. Mutations in *Viola*. Leaflets **1**: 182–184. 30 Ja 1906; 185–187. 24 F 1906.

Greene, E. L. New or noteworthy species. Leaflets **1**: 199, 200. 24 F 1906.
Includes new species in *Dalea*, *Bidens*, and *Aster*.

Greene, E. L. New plants from New Mexico. Leaflets **1**: 211, 212. 10 Ap 1906; 213, 214. 5 Je 1906.
New species in *Ranunculus*, *Erigeron*, *Senecio* (3), *Townsendia*, *Hedeoma*, and *Uropappus*.

Greene, E. L. New species of *Mimulus*. Leaflets **1**: 189, 190. 24 F 1906.
Descriptions of 4 new species.

Greene, E. L. New species of *Viola*. Leaflets **1**: 214–216. 5 Je 1906; 217–219. 16 Je 1906.
Descriptions of 5 new species.

Greene, E. L. *Parthenocissus* a synonym. Leaflets **1**: 219, 220. 16 Je 1906.
Takes up *Psedera* Necker.

Greene, E. L. An unwritten law of nomenclature. Leaflets **1**: 201–205. 10 Ap 1906.

Griggs, R. F. A diurnal rotation in leaves of *Marsilea*. Ohio Nat. **6**: 554, 555. 5 Je 1906.

Grout, A. J. Additions to the bryophyte flora of Long Island. Bryologist **9**: 26–28. 3 Mr 1906.

Grout, A. J. Mosses with hand-lens and microscope. 3: 167–246. *pl. 36–55 + f. 79–133*. New York, Je 1906.

Gürke, M. *Echinocactus Kurtzianus* Gürke n. sp. Monats. Kakteenk. **16**: 55, 56. 15 Ap 1906.
Native of Argentina.

Gürke, M. *Echinocactus Lecontei* Engelm. Monats. Kakteenk. **16**: 12, 13. 15 Ja 1906.

Gürke, M. *Echinocactus longihamatus* Gal. var. *sinuatus* (Dietr.) Web. Monats. Kakteenk. **16**: 56, 57. 15 Ap 1906. [Illust.]

Gürke, M. *Echinocactus Mostii* Gürke n. sp. Monats. Kakteenk. **16**: 11, 12. 15 Ja 1906.
Native of Argentina.

Gürke, M. *Echinocactus Fiebrigii* Gürke. Monats. Kakteenk. **16**: 25–29. 15 F 1906. [Illust.]

Hackel, E. *Gramineae* novae. Repert. Nov. Sp. **2**: 69–72. 1 Mr 1906.

Includes new South American species in *Agrostis* and *Festuca*.

Hamaker, J. I. A culture medium for the zygospores of *Mucor stolonifer*. Science II. **23**: 710. 4 My 1906.

Harper, R. M. A December ramble in Tuscaloosa County, Alabama. Plant World **9**: 102, 104–107. My 1906.

Harper, R. M. A peculiar hygroscopic movement of the capsules of *Kneiffia*. Plant World **8**: 301–303. *f. 59*. [Ja 1906.]

Hayek, A. von. *Verbenaceae* novae herbarii vindobonensis. I. Repert. Nov. Sp. **2**: 86–88. 25 Mr 1906; — II. Repert. Nov. Sp. **2**: 161–164. 15 My 1906.

Includes descriptions of new American species in *Lippia* (4), *Duranta* (2), and *Lantana* (7).

Haynes, C. C. *Cephalozia Francisci* (Hook.) Dumort. Bryologist **9**: 5, 6. *f. 1–3*. 2 Ja 1906.

Hazen, T. E. *Dryopteris Filix-mas* in Vermont. Fern Bull. **14**: 25, 26. [Mr] 1906.

Hill, E. J. *Encalypta procera* — a correction. Bryologist **9**: 32. 3 Mr 1906.

Hitchcock, A. S. Twigs of woody plants. Plant World **9**: 1–7. *f. 1–13*. [F] 1906.

Hollick, A. & Jeffrey, E. C. Affinities of certain Cretaceous plant remains commonly referred to the genera *Dammara* and *Brachyphyllum*. Am. Nat. **40**: 189–214. *pl. 1–5*. 22 Mr 1906.

Holzinger, J. M. *Grimmia glauca* — a new species or a hybrid. Bryologist **9**: 29–31. 3 Mr 1906. [Illust.]

House, H. D. Studies in the North American *Convolvulaceae*. I. Bull. Torrey Club **33**: 313–318. 13 Je 1906.

Includes descriptions of new species in *Jacquemontia*, *Cressa*, and *Evolvulus* (4).

Howe, R. H. *Ramalina rigida* on the Rhode Island coast. Bryologist **9**: 32. 3 Mr 1906.

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Jeffrey, E. C. Morphology and phylogeny. Science II. **23**: 291–297. 23 F 1906.

Jennings, O. E. Additions to the flora of Cedar Point, II. Ohio Nat. **6**: 544, 545. 5 Je 1906.

Jennings, O. E. Some new or noteworthy species reported for Ohio in recent botanical literature. Ohio Nat. **6**: 492–495. 14 Mr 1906.

Jordan, D. S. Concerning variations in animals and plants. Pop. Sci. Mo. **68**: 481–502. Je 1906.

Kellerman, W. A. & York, H. H. Additions to the flora of Cedar Point, I. Ohio Nat. **6**: 541–544. 5 Je 1906.

Klugh, A. B. Notes on the ferns of north-central Ontario. Plant World **8**: 298–301. [Ja 1906.]

Koch, F. J. Floral notes of foreign lands. Plant World **9**: 43–45. [Mr] 1906; 59–62. Mr 1906.

Kränzlin, F. Eine neue Orchidacee aus Süd-Brasilien. Repert. Nov. Sp. **2**: 57. 15 F 1906.

Queckettia australis sp. nov.

Kränzlin, F. *Orchidaceae* andinae imprimis peruvianae Weberbaueri-anae. III. Bot. Jahrb. **37**: 382–398. 24 Ap 1906.

Including new species in *Liparis*, *Orchidotypus* gen. nov., *Masdevallia*, *Epiden-drum*, *Dichaea*, *Pachyphyllum*, *Camaridium*, *Trichoceros*, *Gongora*, *Centropetalum*, *Zygopetalum* (from Paraguay), *Oncidium*, *Odontoglossum* (3), *Pterichis*, *Spiranthes*, *Stenoptera*, *Prescottia*, *Cranichis*, *Sobralia*, *Vanilla*, and *Chloraea* (3).

Krause, K. Novae species andinae *Rutacearum*. Repert. Nov. Sp. **2**: 26, 27. 15 Ja 1906.

Descriptions of new species in *Cusparia* and *Fagara*.

Leavitt, R. G. The blooming of an unusual orchid [*Masdevallia muscosa*]. Plant World **9**: 75–80. *f. 13, 14.* Ap 1906.

Lemmerman, E. Die Pilze der Juncaceen. Abh. Nat. Ver. Bremen **18**: 465–489. Ap 1906.

A list of 219 species of fungi occurring on 55 species of *Juncaceae*.

Leverett, F. The northern limit of the papaw tree. Science II. **23**: 919, 920. 15 Je 1906.

Livingston, B. E. Paraffined wire pots for soil cultures. Plant World **9**: 62–66. *f. 10, 11.* Mr 1906.

Livingston, B. E. A simple method for experiments with water cultures. Plant World **9**: 13–16. *f. 2, 3.* [F] 1906.

McHose, E. D. From the mountains of North Carolina. Am. Bot. **9**: 83–85. [My 1906.]

McOwen, A. Key to Ohio catalpas in winter condition. Ohio Nat. **6**: 496. 14 Mr 1906.

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Includes descriptions of 56 new species in 40 genera.

Merrill, G. K. Lichen notes no. 2. Bryologist **9**: 3, 4. 2 Ja 1906.

Millspaugh, C. F. Praenunciae bahamenses — I. Contributions to the flora of the Bahamian archipelago. Field Columb. Mus. Publ. Bot. **2**: 137–184. 17 F 1906.

New species are described in *Iresine* (2), *Argythamnia* (2), *Euphorbia* (3), *Chiococca*, *Lantana*, *Nashia* gen. nov., *Valerianodes*, *Callicarpa*, *Pseudocarpidium* gen. nov., and *Solanum*.

Morse, W. C. Key to Ohio alders in winter condition. Ohio Nat. **6**: 517. 14 Ap 1906.

Niles, G. G. Old garden flowers and their names. Am. Bot. **9**: 101–106. [My 1906.]

Niles, G. G. Our moccasin flowers and other orchids at home. Plant World **9**: 81–85. *f. 15*. Ap 1906.

Palmer, W. Successful natural parks. Plant World **9**: 8–11. [F] 1906.

Perkins, J. *Styracaceae* americanae novae. Repert. Nov. Sp. **2**: 16–26. 15 Ja 1906.

Descriptions of 15 new species in *Styrax*.

Pettee, E. E. Plant distribution in a small bog. Rep. Mich. Acad. Sci. **7**: 126–128. [1906.] [Illust.]

Pilger, R. *Gramineae* andinae. II. Bot. Jahrb. **37**: 373–381. 24 Ap 1906.

Includes descriptions of new species in *Cortaderia* (2), *Eragrostris* (3), and *Poa* (6).

Pilger, R. *Lamprothyrsus*, eine neue Gattung der Gräser, und ihre Verwandten. Bot. Jahrb. Beibl. **85**: 58–67. 24 Ap 1906.

Based upon *Triraphis Hieronymi* O. Kuntze, native of Argentina and Bolivia.

Pilger, R. *Santalaceae* andinae. Bot. Jahrb. **37**: 398, 399. 24 Ap 1906.

Description of *Arjona glaberrima* sp. nov.

Piper, C. V. The terminology of the parts of the grass spikelet. Science II. **23**: 789, 790. 18 My 1906.

Plowman, A. B. The comparative anatomy and phylogeny of the *Cyperaceae*. Ann. Bot. **20**: 1–33. *pl. 1, 2 + f. 1, 2*. Ja 1906.

Pollock, J. B. Variations in the pollen grain of *Picea excelsa*. Am. Nat. **40**: 253–286. *f. 1–16*. 16 Ap 1906.

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Pond, R. H. The incapacity of the date endosperm for self-digestion. Ann. Bot. **20**: 61–78. Ja 1906.

Purpus, J. A. *Mamillaria chionocephala* J. A. Purpus n. sp. Monats. Kakteenk. **16**: 41–43. 15 Mr 1906. [Illust.]

Quehl, L. *Mamillaria lenta* Brandeg. Monats. Kakteenk. **16**: 40–41. 15 Mr 1906. [Illust.]

Reed, H. S. The parasitism of *Neocosmospora*. Science II. **23**: 751, 752. 11 My 1906.

Rehm, H. *Ascomycetes* Americae borealis. III. Ann. Myc. **3**: 516–520. 10 F 1906.

Includes descriptions of 10 new species in 8 genera.

Rehm, H. *Ascomycetes* exs. fasc. 36. Ann. Myc. **4**: 64–71. 5 Ap 1906.

Includes several American species.

Robinson, C. B. The *Chareae* of North America. Bull. N. Y. Bot. Gard. **4**: 244–308. 13 Je 1906.

Recognizes 50 species, all in the genus *Chara;* of these, 16 are described as new.

Rooney, B. M. The resting of *Botrychium*. Fern. Bull. **14**: 42–44. Ap 1906.

Rosendahl, C. O. Preliminary note on the embryogeny of *Symplocarpus foetidus* Salisb. Science II. **23**: 590. 13 Ap 1906.

Schaffner, J. H. Check list of Ohio trees. Ohio Nat. **6**: 457–461. 15 F 1906.

Schaffner, J. H. The classification of plants. III. Ohio Nat. **6**: 513–516. *pl. 32*. 14 Ap 1906.

Schaffner, J. H. The life cycle of a homosporous pteridophyte. Ohio Nat. **6**: 483–488. *f.* 1. 14 Mr 1906.

Schaffner, J. H. Sexual and non-sexual generations. Ohio Nat. **6**: 473. 15 F 1906.

Schaffner, J. H. Terminology of organs in various conditions of development. Ohio Nat. **6**: 541–544. 5 Je 1906.

Schaffner, J. H. Winter buds of Ohio trees and shrubs. Ohio Nat. **6**: 505–507. 14 Ap 1906.

Schlechter, R. *Orchidaceae* novae et criticae. Decas II. Repert. Nov. Sp. **2**: 129–134. 14 Ap 1906.

Includes descriptions of new species, from Guatemala, in *Habenaria*, *Cranichis* (2), *Spiranthes* (3), *Physurus*, *Epidendrum*, and *Scaphyglottis*. Decas I contained no American species.

Sheldon, J. L. Paraphyses in the genus *Glomerella*. Science II. **23**: 851, 852. 1 Je 1906.

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Squires, W. A. A vegetable tramp [mullein]. Am. Bot. **10**: 30–32. F 1906.

Stockberger, W. W. Furthur notes on *Anthurus borealis*. Ohio Nat. **6**: 517. 14 Ap 1906.

Stone, W. Certain plant "species" in their relation to the mutation theory. Science II. **23**: 701, 702. 4 My 1906.

Sumstine, D. R. Note on *Anthurus borealis*. Ohio Nat. **6**: 474. 15 F 1906.

Sydow, H. & P. Neue und kritische Uredineen — IV. Ann. Myc. **4**: 28–32. 5 Ap 1906.

Includes descriptions of new North American species in *Uromyces* (5) and *Puccinia* (2).

Taylor, E. B. The Georgia bark or quinine tree (*Pinckneya pubens*). Plant World **9**: 39–43. *f. 6.* [Mr] 1906.

Udden, J. A. The northern limit of the papaw tree. Science II. **23**: 920. 15 Je 1906.

Ulbrich, E. *Leguminosae* andinae I. Repert. Nov. Sp. **2**: 1–13. 15 Je 1906.

Includes new species in *Trifolium* (2), *Indigofera* (2), *Dalea* (10), and *Coursetia*.

Ulbrich, E. *Leguminosae* andinae II. Bot. Jahrb. **37**: 416–423. 24 Ap 1906.

Descriptions of 7 new species in *Astragalus*.

Ulbrich, E. *Ranunculaceae* andinae. Bot. Jahrb. **37**: 400–408. *f. 1, 2.* 24 Ap 1906.

Includes descriptions of 2 new species in *Ranunculus*, and a new genus, *Laccopetalum*.

Ulbrich, E. Ueber die systematische Gliederung und geographische Verbreitung der Gattung *Anemone* L. Bot. Jahrb. **37**: 257–334. *pl. 1–3.* 27 F 1906.

Ule, E. Ameisenpflanzen. Bot. Jahrb. **37**: 335–352. 27 F 1906.

Urban, I. Plantae novae andinae imprimis Weberbauerianae. I. Bot. Jahrb. **37**: 373–462. *pl. 9 + f. 1, 2.* 24 Ap 1906.

Consists of 18 separate papers, here indexed under their respective authors: Diels, Graebner, Kränzlin, Pilger, Ulbrich, Zahlbruckner.

Van Hook, J. M. *Ascochyta Pisi* — a disease of seed peas. Ohio Nat. **6**: 507–512. 14 Ap 1906.

Van Hook, M. S. The hop-hornbeam or ironwood. *Ostrya virginiana*. Plant World **9**: 17, 18. [F] 1906.

Vaughan, T. W. The work of Hugo de Vries and its importance in the study of problems of evolution. Science II. **23**: 681–691. 4 My 1906.

Vaupel, F. Reisebilder. Tagebuchskizzen aus der Alten und Neuen Welt. Monats. Kakteenk. **16**: 1–4. 15 Ja 1906; 19–22. 15 F 1906; 35–38. 15 Mr 1906; 51–55. 15 Ap 1906.

Walter, H. Die Diagramme der Phytolaccaceen. Bot. Jahrb. Beibl. **85**: 1–57. *f. 1–92.* 24 Ap 1906.

Weed, C. M. Trees in winter — I. [The maple family.] Forest & Stream **66**: 15. 6 Ja 1906; — II. The ash family. Forest & Stream **66**: 92. 20 Ja 1906; — III. The walnut and hickory family. Forest & Stream **66**: 134. 27 Ja 1906. [Illust.]

Weed, C. M. Trees in winter — IV. The birches. Forest & Stream **66**: 222, 223. 10 F 1906; — V. The locust family. Forest & Stream **66**: 343. 3 Mr 1906; — VI. The oak family. Forest & Stream **66**: 499, 500. 31 Mr 1906. [Illust.]

Weed, C. M. Wild cherries. Forest & Stream **66**: 789. 19 My 1906. [Illust.]

Weingart, W. *Cereus horridus* Otto. Monats. Kakteenk. **16**: 59–62. 15 Ap 1906.

Weingart, W. *Cereus Jusbertii* Reb. Monats. Kakteenk. **16**: 79. 15 My 1906.

White, C. A. The black locust tree and its despoliation. Pop. Sci. Mo. **68**: 211–218. Mr 1906.

White, C. A. The northern limit of the papaw tree. Science II. **23**: 749–751. 11 My 1906.

Whittlesey, O. The devil's tongue [*Amorphophallus Rivieri*]. Plant World **9**: 18–20. [F] 1906.

Wiegand, K. M. The occurrence of ice in plant tissue. Plant World **9**: 25–39. *f. 4, 5.* [Mr] 1906.

Wiegand, K. M. The passage of water from the plant cell during freezing. Plant World **9**: 107–118. *f. 18.* My 1906.

Winslow, E. J. The distribution of *Botrychia.* Fern Bull. **14**: 48, 49. Ap 1906.

Young, R. A. Key to the Ohio viburnums in the winter condition. Ohio Nat. **6**: 551, 552. 5 Je 1906.

Zahlbruckner, A. *Campanulaceae* andinae. Bot. Jahrb. **37**: 451–462. 24 Ap 1906.

Includes descriptions of new species in *Burmeistera, Centropogon* (4), *Siphocampylus* (7), *Rhizocephalum,* and *Lobelia* (2).